

Logic Families

presented by

Dr. Ramesh Manza

M.Sc., Ph.D., SET, NET, FIETE, IAEng, CSTA, IACSIT, ISSS, Senior Member

IEEE, ISCA, IUPRAI

Associate Professor,

Bio-Medical Image Processing Laboratory

Department of Computer Science and Information Technology,

Dr. Babasaheb Ambedkar Marathwada University,

Aurangabad. 431004(MS) India

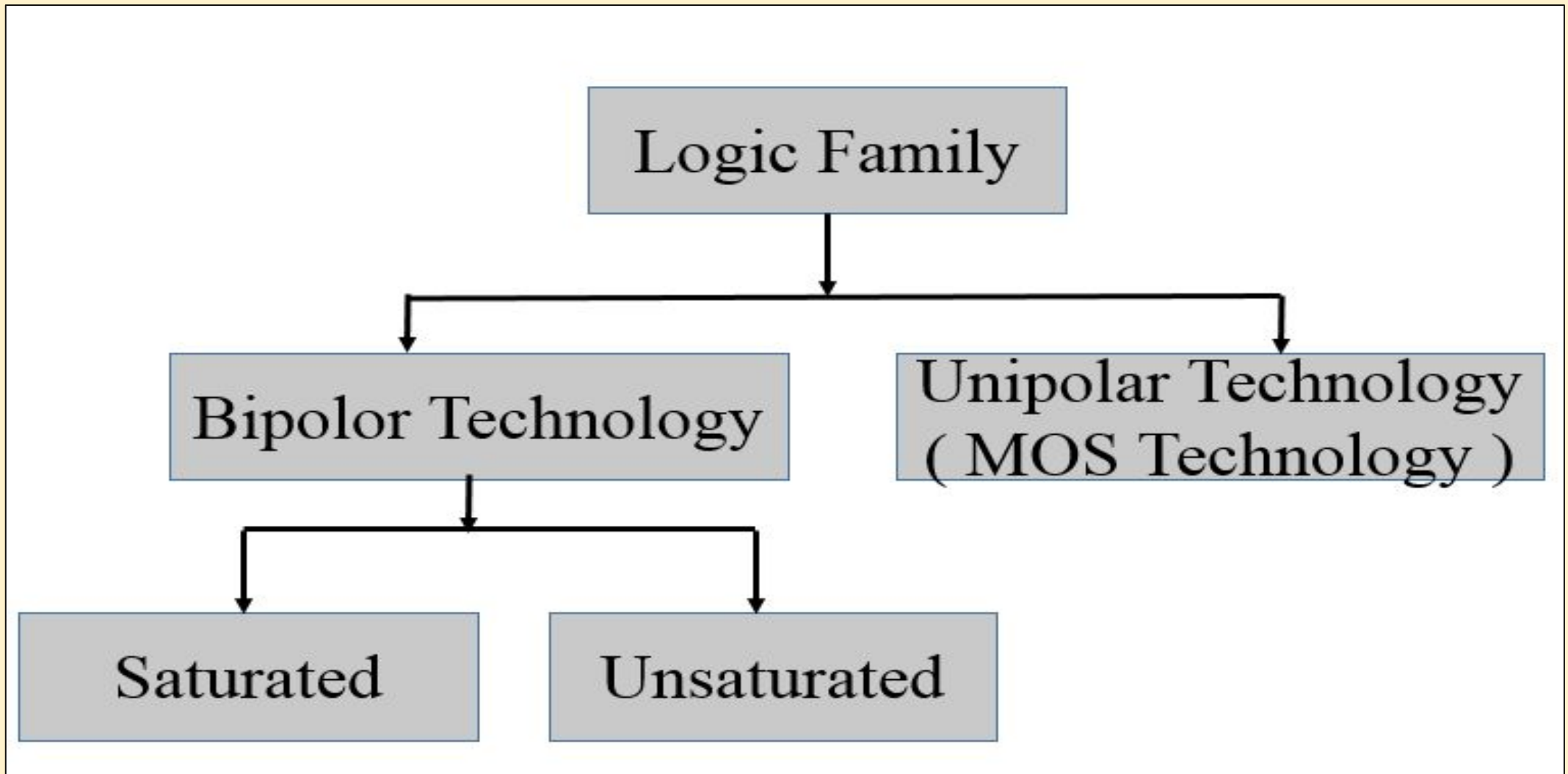
Logic Families

- Semiconductor **devices can be fabricated using** two technologies –
 - a) Bipolar Technology
 - b) Unipolar Technology (or MOS Technology)

Bipolar technology again **classified into** two types –

- a) Saturated
- b) Unsaturated

Classification of Logic Family



Logic Families

a) Bipolar Technology :-

- ✓ **Uses diodes** (transistor) and BJT for fabricating circuits.
- ✓ **Fast** in operation.
- ✓ **Consume** lot of power.
- ✓ **Good switching** speed.

b) Unipolar Technology (or MOS Technology) :-

- ✓ **Uses FETs** (Field Effect Transistors) or **MOSFETS** (Metal Oxide Semiconductor FET) for circuit fabrication.
- ✓ **Slow** in operation.
- ✓ **Less power** required.
- ✓ **Better packing** density.
- ✓ **Eg. :-** PMOS, NMOS, CMOS

Logic Families

a) Saturated :-

- ✓ Transistors are **driven into saturation** (full conduction).
- ✓ Thus, transistors **take some time to switch** from saturation (full conduction) to cut off (no conduction).
- ✓ **Eg. :-** TTL, I²L, HTL, RTL, DTL

b) Unsaturated :-

- ✓ **Transistors switches between** conduction and no conduction .
- ✓ **Faster because** the transistors are **never driven into** full conduction or full non-conduction.
- ✓ **Eg. :-** ECL, Schottky TTL

Full Forms – Logic Families

FET – Field Effect Transistor

MOSFET – Metal Oxide Semiconductor FET

TTL – Transistor – Transistor Logic

I²L – Integrated Injection Logic

HTL – High Threshold Logic

DTL – Diode Transistor Logic

RTL – Resistor Transistor Logic

ECL – Emitter Coupled Logic

PMOS – P Channel Metal Oxide Semiconductor Field Effect Transistor

NMOS - N Channel Metal Oxide Semiconductor Field Effect Transistor

CMOS – Complementary (both P Channel and N Channel) Metal Oxide Effect Transistor

Parameters of Logic Families

1. Logic levels
2. Switching speed
3. Propagation delay
4. Power dissipation
5. Noise margins
6. Fan out and Fan in

Parameters of Logic Families

1. **Logic levels** :- Logic levels refer to the voltages and currents that represent logic 1 or logic 0.

For TTL family □ logic 0 □ 0 V □ 0.4 V
logic 1 □ 2.4 V □ 5 V

For MOS family □ logic 0 □ 0 V
logic 1 □ 1 = Supply voltage V_{cc}

CMOS IC can be operated for supply range of 3V to 15 V.

TTL IC operated at 5V.

Parameters of Logic Families

2. Switching speed :-

- ✓ It decides the **speed of operation of a gate** and hence **in general** the **response of a gate** to the given input.
- ✓ The switching speed is **specified in terms of propagation delay** time.
- ✓ **Smaller the propagation** delay, **faster is the speed** of operation of a logic circuit.
- ✓ **TTL** logic family **has higher switching speed** as compared to MOS logic family.

Parameters of Logic Families

3. Propagation delay :-

- ✓ Whenever some **input is applied** to a logic gate, **it takes some time** for the transistors (BJT or FET) **to be respond** switch its state **and produce a stable output**. This time is called, “propatation delay”.
- ✓ The propagation delay of gate **is the average transition delay time** for the signal **to propagate from input to output** It is **measured in nanoseconds**.
- ✓ The **shorter** the propagation **delay**, **faster** will be the operation of **the device**.
- ✓ In general, **BJT based circuit have good switching speed** and hence is the faster.
- ✓ Between TTL and ECL, **circuit based on ECL are the faster** as the **transistors are never in full saturation or full cut-off**. Hence, switching from one condition to other is faster.
- ✓ **FET or MOSFET based circuits are slower** in switching states.
- ✓ Propagation delay **in ECL is smallest**. So they have **very fast** switching speed.

Parameters of Logic Families

4. Power dissipation :-

- ✓ It is a measure of **the amount of power utilize** by the gate for its operation.
- ✓ The power dissipation **is defined as power needed** by the logic circuit.
- ✓ A **BJT requires more power** for its operation than FET or MOSFET. Hence, **TTL based circuits** dissipate **more power** than FET based circuits.
- ✓ **TTL consumes lot of power** for its operation.
- ✓ **MOSFET consumes litter power** and have **better packaging density**.

Parameters of Logic Families

5. Noise margins :-

- ✓ A noise refers to **unwanted sudden signals**.
- ✓ The **ability of logic circuit to tolerate** noise signals (it means **presence of noise doesn't change** the output of logic gate) is **called** , its **noise immunity**.
 - When this information is **expressed quantitatively in terms of current or voltage** it is **called**, “ noise margin”. The **quantative measure of noise immunity** is called noise margin.
- ✓ Noise margin **can be DC or AC noise margin**.
- ✓ A noise is **generally a AC signal with** some amplitude and pulse rate.
- ✓ If **pulse width of noise is greater than or equal to propagation** delay of logic circuit, **then the noise is treated as DC** noise.
- ✓ If **pulse width of noise is less** than propagation delay of logic circuit, the **duration of noise is to small** for a circuit to respond. This means the **circuit can with stand a noise** of specific amplitude **if it has a pulse** width.

Parameters of Logic Families

6. Fan out and Fan in :-

- ✓ **Fan in** :- Number of inputs that a logic gate can handle properly without disturbing the output level. .
- ✓ It is a number of gates that can provide inputs to a driving gate.

- ✓ **Fan-Out** :- Fan-out is a logic gate refers to the maximum number of loads (gates) . A gate can drive without affecting the working of the gates.
- ✓ It is the number of gates which can be driven by a driver gate simultaneously by the output without disturbing the output level.

CMOS - Complementary MOS

- CMOS logic family **uses** CMOS (**Complementary MOS**) transistor.
- CMOS **uses both** P channel and N channel MOSFET.

- **CMOS or CMOSFET Advantages :-**
 - ✓ **High** input impedance
 - ✓ **Good** packaging density.
 - ✓ Very **low power** dissipation.
 - ✓ **Suitable for** operation with **batteries**.

ECL – Emitter Couple Logic

- ECL (Emitter Coupled Logic) can **also be named as** CML(Collector Mode Logic).
- ECL is **non saturated digital** logic family.
- The **output of ECL provides OR and NOR** function. **Each input is connected to the base of transistor.**
- **Characteristics :-**
 - ✓ Propagation **delay is very LOW**(<1ns)
 - ✓ ECL is **fastest** logic family.
 - ✓ ECL circuit **usually operate with –Ve supplies** (+Ve terminal is **connected to ground**).

RTL – Resistor Transistor Logic

- RTL is the first logic family which is **not available in monolithic** form.
- The **basic circuit** of the RTL logic family **is the NOR**.
- Each **input is associated** with **one resistor** and **one transistor**.
- The **collector of the transistor** are **tied together** at the **output**.
- The **voltage levels** for the circuit are **0.2v** for the low level and **from 1 to 3.6v** for the high level.

TTL - Transistor- Transistor Logic

- It can perform many digital function and have achieved the most popularity.
- TTL IC are given the numerical designation as 5400 and 7400 series.
- The basic circuit of TTL with totem pole output stage is NAND gate.
- TTL uses a multi-emitter transistor at the input and is fast saturation logic circuit.
- The output transistor Q3 and Q4 form a totem-pole connection. This extra output stage is known as totem-pole stage because three output components Q3 and Q4 and Diode are stacked on one another.
- **Characteristics :-**
 - ✓ TTL has greater speed than DTL.
 - ✓ Less noise immunity.
 - ✓ Power dissipation is 10mw.
 - ✓ It has fan-in of 6 and fan-out of 10.
 - ✓ Propagation time delay is 5-15nsec.

DTL – Diode Transistor Logic

- DTL was **first commercial available IC** logic family in 53/73 series.
- The **basic circuit** in the DTL logic is the **NAND** gate.
- Each **input associated with** one diode.
- The **diode and resistor form an** AND gate.
- The **transistor services as a** NOR gate.

- **Characteristics :-**
 - a) It has **fan-out of 8**.
 - b) It has **high noise** immunity.
 - c) **Power dissipation is 12mw**.
 - d) **Propagation delay** is average 30ns.
 - e) **Noise margin** is about 0.7V.

Questions on Logic Families

1. Which of the following logic has the maximum fan out ?

- a) RTL
- b) ECL
- c) NMOS
- d) CMOS

[NET Jun 2005, Q. 8]

[NET Jun 2006 Q. 8]

Questions on Logic Families

1. Which of the following logic has the maximum fan out ?

- a) RTL
- b) ECL
- c) NMOS
- d) CMOS

[NET Jun 2005, Q. 8]

[NET Jun 2006 Q. 8]

Answer :- d) CMOS

Questions on Logic Families

2. Which of the following logic is the fastest ?

- a) RTL
- b) ECL
- c) HTL
- d) HCL

[NET Dec. 2006, Q. 10]

Questions on Logic Families

2. Which of the following logic is the fastest ?

- a) RTL
- b) ECL
- c) HTL
- d) HCL

[NET Dec. 2006, Q. 10]

Answer :- b) ECL

Explanation :- Transistors used in ECL are in different amplifier configuration in which they never driven into saturation and so storage time is eliminated.

Questions on Logic Families

3. Among the logic families DTL, TTL, ECL and CMOS the family with the least power dissipation.

- a) CMOS
- b) DTL
- c) TTL
- d) ECL

[NET Dec. 2007, Q. 10]

Questions on Logic Families

3. Among the logic families DTL, TTL, ECL and CMOS the family with the least power dissipation.

- a) CMOS
- b) DTL
- c) TTL
- d) ECL

[NET Dec. 2007, Q. 10]

Answer :- a) CMOS

Questions on Logic Families

4. Among the logic families RTL, TTL , ECL and CMOS the fastest family is -

- a) ECL
- b) CMOS
- c) TTL
- d) RTL

[NET Jun. 2008, Q. 7]

Questions on Logic Families

4. Among the logic families RTL, TTL , ECL and CMOS the fastest family is -

- a) ECL
- b) CMOS
- c) TTL
- d) RTL

[NET Jun. 2008, Q. 7]

Answer :- a) ECL

Questions on Logic Families

5. Extremely low power dissipation and low cost per gate can be achieved in

- a) MOS ICS
- b) CMOS ICS
- c) TTL ICS
- d) ECL ICS

[NET Dec 2008, Q. 4]

Questions on Logic Families

5. Extremely low power dissipation and low cost per gate can be achieved in

- a) MOS ICS
- b) CMOS ICS
- c) TTL ICS
- d) ECL ICS

[NET Dec 2008, Q. 4]

Answer :- b) CMOS ICS

Questions on Logic Families

6. Which of the following logic families is well suited for high-speed operations ?

- a) TTL**
- b) ECL**
- c) MOS**
- d) CMOS**

[NET Jun 2012 , P- II , Q. 36]

Questions on Logic Families

6. Which of the following logic families is well suited for high-speed operations ?

- a) TTL**
- b) ECL**
- c) MOS**
- d) CMOS**

[NET Jun 2012 , P- II , Q. 36]

Answer :- b) ECL

Questions on Logic Families

7. CMOS circuits consume power

- a) Equal to TTL
- b) Less than TTL
- c) Twice of TTL
- d) Thrice of TTL

Questions on Logic Families

7. CMOS circuits consume power

- a) Equal to TTL
- b) Less than TTL
- c) Twice of TTL
- d) Thrice of TTL

Answer :- b) Less than TTL

Explanation :- As in CMOS , one device is ON and One is always OFF, so power consumption is low.

Questions on Logic Families

8. In ECL the fan-out capability is _____

- a) High
- b) Low
- c) Zero
- d) Sometimes high and sometimes low

Questions on Logic Families

8. In ECL the fan-out capability is _____
- a) High
 - b) Low
 - c) Zero
 - d) Sometimes high and sometimes low

Answer :- a) High

Explanation :- If the input impedance is high and the output resistance is low; as a result, the transistors change states quickly, gate delays are low, and the fan-out capability is high. Fan-out is the measure of the maximum number of inputs that a single gate output can accept.

Questions on Logic Families

- 9. Which among the bipolar logic families is specifically adopted for high speed applications ?**
- a. Diode Transistor Logic (DTL)**
 - b. Transistor Transistor Logic (TTL)**
 - c. Emitter Coupled Logic (ECL)**
 - d. Integrated Injection Logic (I²L)**

Questions on Logic Families

- 9. Which among the bipolar logic families is specifically adopted for high speed applications ?**
- a. Diode Transistor Logic (DTL)**
 - b. Transistor Transistor Logic (TTL)**
 - c. Emitter Coupled Logic (ECL)**
 - d. Integrated Injection Logic (I²L)**

Answer :- Emitter Coupled Logic (ECL)

Questions on Logic Families

- 10. Which type of unipolar logic family exhibits its usability for the applications requiring low power consumption?**
- a. PMOS**
 - b. NMOS**
 - c. CMOS**
 - d. All of the above**

Questions on Logic Families

10. Which type of unipolar logic family exhibits its usability for the applications requiring low power consumption?

- a. PMOS**
- b. NMOS**
- c. CMOS**
- d. All of the above**

Answer :- c) CMOS

Questions on Logic Families

- 11. Which type of unipolar logic family exhibits its usability for the applications requiring low power consumption?**
- a. PMOS**
 - b. NMOS**
 - c. CMOS**
 - d. All of the above**

Questions on Logic Families

11. Which type of unipolar logic family exhibits its usability for the applications requiring low power consumption?

- a. PMOS**
- b. NMOS**
- c. CMOS**
- d. All of the above**

Answer :- c) CMOS

Questions on Logic Families

12. ECL's major disadvantage is that _____

- a) It requires more power
- b) It's fan-out capability is high
- c) It creates more noise
- d) It is slow

Questions on Logic Families

12. ECL's major disadvantage is that _____

- a) It requires more power
- b) It's fan-out capability is high
- c) It creates more noise
- d) It is slow

Answer :- a) It requires more power

Explanation :- ECL's major disadvantage is that **each gate continuously draws current**, which **means it requires** (and dissipates) **significantly more power** than those of other logic families. **But ECL logic gates have** clock frequency. **Thus**, they **have a fast** operation.

Questions on Logic Families

13. The ECL circuits usually operates with _____

- a) Negative voltage
- b) Positive voltage
- c) Grounded voltage
- d) High Voltage

Questions on Logic Families

13. The ECL circuits usually operates with _____

- a) Negative voltage
- b) Positive voltage
- c) Grounded voltage
- d) High Voltage

Answer :- a) Negative voltage

Explanation :- The ECL circuits usually operate with negative power supplies (**positive end of the supply is connected to ground**), in comparison to other logic families in which negative end of the supply is grounded. **It is done mainly to minimize the influence of the power supply variations on the logic levels as ECL is more sensitive to noise on the VCC and relatively immune to noise on VEE.**

Questions on Logic Families

14. **The ECL behaves as _____**

- a) NOT gate
- b) NOR gate
- c) NAND gate
- d) AND gate

Questions on Logic Families

14. The ECL behaves as _____

- a) NOT gate
- b) NOR gate
- c) NAND gate
- d) AND gate

Answer :- b) NOR gate

Explanation :- The ECL behaves as NOR gate because if any of the input voltages go high as compared to the reference voltage, the output is low and the output is high only when all the input voltages are low.

Questions on Logic Families

15. In an ECL the output is taken from _____
- a) Emitter
 - b) Base
 - c) Collector
 - d) Junction of emitter and base

Questions on Logic Families

15. In an ECL the output is taken from _____

- a) Emitter
- b) Base
- c) Collector
- d) Junction of emitter and base

Answer :- c) Collector

Explanation :- Though, the emitter and collector of the ECL are coupled together. So, the **output will be taken from a collector.**

Questions on Logic Families

16. Sometimes ECL can also be named as _____

- a) EEL
- b) CEL
- c) CML
- d) CCL

Questions on Logic Families

16. Sometimes ECL can also be named as _____

- a) EEL
- b) CEL
- c) CML
- d) CCL

Answer :- c) CML

Explanation :- ECL (Emitter Coupled Logic) can also be named as **CML**(Collector Mode Logic).

Questions on Logic Families

17. Which logic is the fastest of all the logic families ?

- a) TTL
- b) ECL
- c) HTL
- d) DTL

Questions on Logic Families

17. Which logic is the fastest of all the logic families ?

- a) TTL
- b) ECL
- c) HTL
- d) DTL

Answer :- b) ECL

Explanation :- ECL is the fastest of all the logic families because of the emitters of many transistors are coupled together which results in the highest transmission rate.

Questions on Logic Families

18. The full form of ECL is _____

- a) Emitter-collector logic
- b) Emitter-complementary logic
- c) Emitter-coupled logic
- d) Emitter-cored logic

Questions on Logic Families

- 18. The full form of ECL is _____**
- a) Emitter-collector logic
 - b) Emitter-complementary logic
 - c) Emitter-coupled logic
 - d) Emitter-cored logic

Answer :- c) Emitter-coupled logic

Questions on Logic Families

19. Extremely low power dissipation and low cost per gate can be achieved in

- (A) MOS ICS
- (B) C MOS ICS
- (C) TTL ICS
- (D) ECL ICS

[NET, Dec. 2008, PAPER II, Q. 4]

Questions on Logic Families

19. Extremely low power dissipation and low cost per gate can be achieved in

- (A) MOS ICS
- (B) C MOS ICS
- (C) TTL ICS
- (D) ECL ICS

[NET, Dec. 2008, PAPER II, Q. 4]

Answer :- (B) CMOS ICS

Questions on Logic Families

- 20. Which of the following logic families is well suited for high-speed operations ?**
- (A) TTL
 - (B) ECL
 - (C) MOS
 - (D) CMOS

Questions on Logic Families

20. Which of the following logic families is well suited for high-speed operations ?

- (A) TTL
- (B) ECL
- (C) MOS
- (D) CMOS

Answer :- (B) ECL

Explanation :- ECL stands for **Emitter-Coupled Logic**. It is **designed for extremely high speed** application. It is **well suited for large mainframe computer** that require **high number of operation** per second.

Questions on Logic Families

21. Match the following IC families with their basic circuits :

a. TTL

1. NAND

b. ECL

2. NOR

c. CMOS

3. Inverter Code : a b c

(A) 1 2 3

(B) 3 2 1

(C) 2 3 1

(D) 2 1 3

Questions on Logic Families

21. Match the following IC families with their basic circuits :

- | | |
|---------|--------------------------|
| a. TTL | 1. NAND |
| b. ECL | 2. NOR |
| c. CMOS | 3. Inverter Code : a b c |

- (A) 1 2 3
(B) 3 2 1
(C) 2 3 1
(D) 2 1 3

Answer :- (A) 1 2 3

Explanation :-

TTL :- NAND

ECL :- NOR

CMOS :- Inverter Code : a b c

Questions on Logic Families

22. Match the following : from position p1, position p2

- | | |
|---------|---------------------------|
| a. TTL | 1. High fan out |
| b. ECL | 2. Low propagation delay |
| c. CMOS | 3. High power dissipation |

Code :

- | | a | b | c |
|-----|---|---|---|
| (A) | 3 | 2 | 1 |
| (B) | 1 | 2 | 3 |
| (C) | 1 | 3 | 2 |
| (D) | 3 | 1 | 2 |

Questions on Logic Families

22. Match the following : from position p1, position p2

- | | |
|---------|---------------------------|
| a. TTL | 1. High fan out |
| b. ECL | 2. Low propagation delay |
| c. CMOS | 3. High power dissipation |

Code :

- | | a | b | c |
|-----|---|---|---|
| (A) | 3 | 2 | 1 |
| (B) | 1 | 2 | 3 |
| (C) | 1 | 3 | 2 |
| (D) | 3 | 1 | 2 |

Answer :- (A) 3 2 1

Explanation :-

TTL :- High power dissipation

ECL :- Low propagation delay

CMOS :- High fan out

- Discussion

Thank You